

Note about the impact possibilities of asteroid (99942) Apophis

by

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A B S T R A C T

The Monte Carlo method of the nominal orbit cloning was applied to the case of 99942 Apophis, the asteroid from the Aten group. Calculations based on observations from the time interval of 20040315 - 20080109 have shown that the asteroid will pass near Earth in 2029 at the minimum distance of $5.921 \pm 0.042 R_{\text{Earth}}$, what implies that the likelihood that Apophis strikes the planet at 2036 April 13 increased to 4.5×10^{-6} (from about 6×10^{-7} previously announced by us in Paper I (Królikowska, Sitarski, and Sołtan 2009)). This value is identical with that given by Chesley, Baer, and Monet (2010).

1. Introduction

This note is motivated by the the article *Treatment of star catalogue biases in asteroid astrometric observation* by Chesley, Baer, and Monet (2010). That paper presents interesting discussion about systematic errors in star positions of the USNO series of star catalogs often used to reduce the astrometric observations of currently observed asteroids in recent years. In the abstract, the authors wrote that the inclusion of the proposed debiasing techniques to improve the astrometric observations of the asteroid 99942 Apophis reduces the impact probability "by nearly an order of magnitude to 4.5×10^{-6} for the 2036 close approach".

Earlier this year we released a new analysis of the asteroid Apophis collision in our Web Page (Królikowska and Sitarski 2010) (in February 2010) and in the Magazine of Polish Academy of Science (Królikowska and Śliwa 2009). The first source (website) mainly presents examples of the orbital elements of the impact orbits for potentially dangerous future dates. However, we would like now to show that our method of weighting the observations seems to effectively eliminate problems associated with the existence of systematic biases in some sequences of observations for asteroid Apophis case.

2. The method

Results presented here are based on the archive positional observations taken from the NEODyS (Near Earth Object - Dynamic Site, University of Pisa, Italy) available on the Web at <http://newton.dm.unipi.it/neodys/>. The whole observational material contained 1399 observations covering the time period from March 15, 2004 to January 9, 2008. The data were taken from NEODyS source at the end of 2009. However, the current observation interval has not changed (September 14, 2010).

Our method of the data treatment as well as the full method of impact orbit determination are described in details in Paper I. Therefore, current results differ from that paper only because of longer arc of observations and much greater number of observations. We derived the nominal orbit using this longer arc with $\text{rms} = 0.270$ arcsec (2774 residuals).

3. Results

The distribution of minimum asteroid distance from Earth is presented for the current solution by magenta filled histogram in Fig. 1. The minimum-distance histograms for shorter arc (best Model E from the Paper I) is shown with a blue solid line.

We obtained 45 impact orbits from the sample of 10^7 VAs (Virtual Asteroids) for the Earth encounter on April 13, 2036 using the methods described in details in Paper I. Thus, the impact probability of $\sim 4.5 \cdot 10^{-6}$ was calculated for the current solution. The best solution in the Paper I (Model E) gave the probability of a collision in 2036 at the level of $\sim 6 \times 10^{-7}$, which is almost an order of magnitude smaller than the current solution based on the longer arc of observations. This is explained in Fig. 1. Figure 1 also shows that the impact possibilities in 2037 and years related to the close encounter in 2037 should now be excluded because of practically zero likelihood of such events (while in Model E from the Paper I the impact probability in 2037 was about four times greater than probability for the year 2036).

The coincidence of our impact probability value for a potential collision in 2036 for the Apophis case with the value obtained by Chesley, Baer, and Monet (2010) indicates that our weighting procedure of observations seems to effectively tackle problems associated with the existence of systematic biases in some sequences of observations.

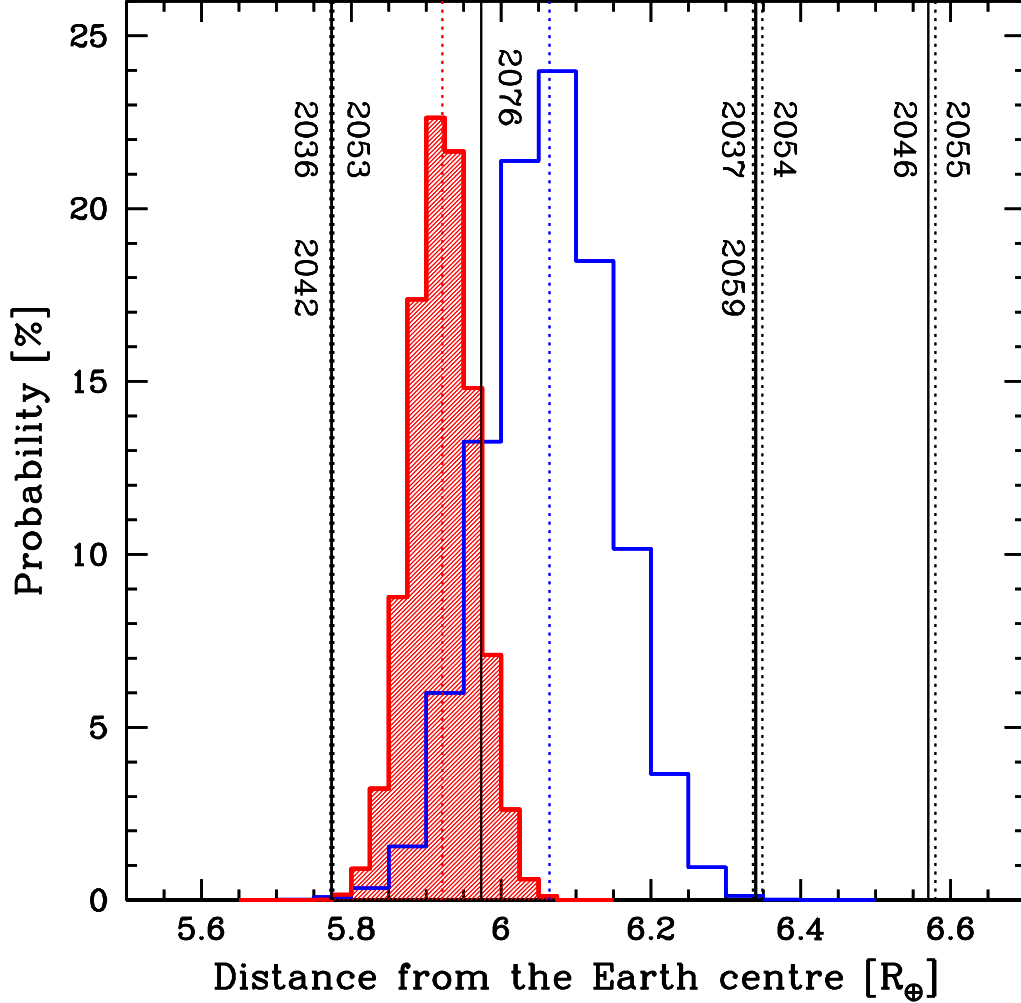


Figure 1: Distributions of the minimum distance of the asteroid Apophis from the centre of Earth in 2029 04 13 derived for the samples of 15 000 virtual orbits. The blue histogram shows results based on a shorter observational arc (Model E from the Paper I), while for the current model based on longer arc is shown with a red solid line and filled histogram. Thin dotted vertical lines represent the position of nominal orbits derived for Model E and for current model and are shown with a blue and red ink, respectively. Solid and dashed black vertical lines represent gravitational keyholes, marked with dates of possible future collisions. The possible collision in 2076 could only occur if preceded by a flyby at a very precise distance in 2051. Thus, the 2029 keyhole for the impact in 2076 is extremely small and the probability of such collision turns out to be significantly smaller than the probability of impact in 2036.

Bibliography

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